

CALIFORNIA DEPARTMENT OF TRANSPORTATION

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A Letter to Readers

I am extremely grateful to the dedicated men and women of our agency for their professional contribution to the safety of California's motorists. The departments within the Business, Transportation and Housing Agency comprise the Governor's principal transportation regulatory and enforcement organizations. By combining their resources, we are making driving safer, as evidenced by the fact that the number of fatalities per miles traveled is now the lowest in the state's history.

As Secretary for Transportation, I am committed to having the best traffic safety programs possible, including anti-DUI, bicycle and pedestrian safety, occupant protection, police traffic services, roadway safety and emergency medical services. These programs and so many others are helping California achieve its traffic safety successes, such as having the highest seat belt compliance rate in the nation.



Maria
Contreras-Sweet

I have a charge from Governor Gray Davis to improve safety on California's roadways. That means relieving traffic congestion, thus affording people more quality time for work and family life. We all enjoy getting home quickly and safely after a hard day's work.

One of our shared goals is to alleviate traffic congestion by stopping unsafe driving behaviors that contribute to accidents. Through funding for more law enforcement personnel and equip-

ment, emergency response vehicles and public education, we will make our roads even safer. We are also excited about the new partnerships being established with community-based organizations in California. This innovation will expand our outreach enormously. The Governor recently awarded \$11.8 million to local community-based organizations to promote traffic safety programs.

Traffic safety is everyone's business. Governor Davis and I look forward to working with all of you to improve the quality of life for all Californians.

A stylized, handwritten signature in white ink that reads "Maria Contreras-Sweet". The signature is fluid and cursive, with the first name being the most prominent.

Maria Contreras-Sweet

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Putting Aerospace Technology to Work in Civil Engineering

The Kings Stormwater

Civil Engineers are fond of saying that what they do is not "rocket science."

Move over, Wernher Van Braun.

Caltrans, together with the aerospace industry and the University of California at San Diego, has just embarked on construction of an experimental bridge that uses aerospace industry-developed carbon-fiber materials for longitudinal girders and fiberglass for the bridge deck. Although not the first use of these materials on a bridge, it is the first on a major highway with heavy truck traffic. Route 86 is a major route for movement of goods to and from post-NAFTA Mexico.

The bridge, on State Route 86 over the Kings Stormwater Channel at the north end of the Salton Sea, is composed of two 9.75 m (32 ft.) spans, 12.8 m (42 ft.) wide, resting on concrete abutments and bents.

UC San Diego designed the bridge in conjunction with the Division of Structure Design. John Pagano and Paul Stevens of Caltrans were project managers for the highway project of which the bridge is a part.

"This is probably the first time in recent history that we were able to do full-scale testing in the laboratory before construction of a structure," says Earl Seaberg, Caltrans Structures Design Engineer. "We tested it at four times the design loadings, and we couldn't make it fail."

Use of the materials was first suggested to UC San Diego bridge expert Frieder Seible by the U. S. Department of Defense. Defense, concerned that the industries it had



Channel Bridge



Photos by Don Tateishi

spawned for the Cold War could not be sustained any longer on aerospace alone, went hunting for uses to which the materials could be applied in an effort to keep those industries viable.

In 1996, the Defense Department suggested to Seible a project whose cost could be shared by the Defense Advanced Research Projects Agency, the aerospace industry, the UC system and Caltrans. Alliant Technical Systems of Salt Lake City, Utah, and Martin Marietta Materials in Raleigh, North Carolina, supplied the materials. Seible tried out the idea on Caltrans Deputy Director Jim Roberts, who sent his Structures Division looking for a suitable application.

"This bridge is a precursor to a composite cable stayed bridge over Interstate 5 at Gilman Drive in San Diego," says Seaberg. "We wanted a project with a suitably short

"This is probably the first time in recent history that we were able to do full-scale testing in the laboratory before construction of a structure..."

span where we could monitor its performance before trying a more ambitious project. We didn't know much about composite materials and the Defense Department and the composite industry didn't know much about bridges. The Route 86 site was the most promising."

Together with the University, Structures developed a bridge that used carbon-fiber tubes, about 355 mm in diameter, as the main longitudinal structural elements, and a fiberglass bridge deck.

The tubes are manufactured by passing woven carbon-fiber cloth filaments derived from heating artificial or

Carbon fiber

Carbon fiber, a polymer, is a form of graphite, which is a form of pure carbon in which carbon atoms are arranged in sheets of hexagonal rings that look like chicken wire.

In carbon fiber, these sheets are long and thin. You might think of them as ribbons of graphite. When bunches of these ribbons pack together, they form fibers, hence the name carbon fiber.

Carbon fibers are not used by themselves. Instead, they're used to reinforce materials such as epoxy resins and other thermosetting materials. We call these reinforced materials composites because they have more than one component.

Carbon fiber-reinforced composites are very strong for their weight. They're often stronger than steel, but much lighter. Because of this, they can be used to replace metals in many uses, from parts for airplanes and the space shuttle to tennis rackets and golf clubs.

The tube-deck panel combination was so strong that testers at UC San Diego could not make it fail.



natural organic compounds to high temperatures through a resin bath and then winding them onto a mandrel, or large spool. When the winding is complete, the carbon-fiber tube is heat-cured to provide necessary strengths and the mandrel is extracted.

The tubes, six for each span, are filled with concrete to increase mass and enhance the load transfer within the tube. These are supported on conventional concrete abutments and bent supports. The tubes are connected to the supports with reinforcing steel.

The deck panels are built up from components that are manufactured by a process called "pultrusion" (the opposite of "extrusion") by pulling fiberglass material through a resin bath and curing oven. The fiberglass is the same material that is found in a wide variety of everyday applications, such as ladders, boats and cars. Special protection is required to guard it from exposure to nature's elements.

The panels are of a web design that is 3 m long and 12.8 m wide, and are anchored to the tubes by steel dowels protruding from the tops of the tubes. Concrete provides shear transfer between the tubes and the deck. After the deck is anchored down, a riding surface of 20 mm of polymer concrete is overlaid on the deck.

Because of the bridge's unique construction, particularly its weight, which is about a quarter that of a comparable conventional bridge, Caltrans was able to do full-scale testing in UC San Diego's structural testing facility. The lab applied cyclic load testing to determine the

bridge's strength, applying two million cycles of repetitive load application.

"We couldn't make it fail," says Seaberg. "We got to four times the design load and couldn't apply any more due to the capacity of the testing equipment." The bridge was tested for structural characteristics of the tube, plus all systems – tube-to-deck connections; barrier rail-to-deck connections; tube-to-support connections; overall performance under load; fatigue and seismic performance.

While the performance of the bridge under testing was highly satisfactory, many questions remain. The bridge will be instrumented for actual load testing, and monitored under use for several years. The Kings Stormwater Channel was chosen because it provided a location where the technology could be tested on short spans; Caltrans bridges typically have 30 to 60 m spans. How the material will perform on spans like those must be determined.

Testing indicates that the structure's response in a seismic event would be superior to that of a conventional bridge; however, its performance in an actual seismic event obviously has yet to be evaluated. The carbon composite material has a

“This technology shows a great deal of promise,” says Seaberg. “It’ll be several years before we have a picture of just how much promise it does have, but we are already using carbon composites and fiberglass column jackets for seismic retrofits.”

very low coefficient of thermal expansion. Using it in conjunction with other materials that have higher coefficients of expansion, such as concrete or steel, will be one of the challenges we face as engineers.

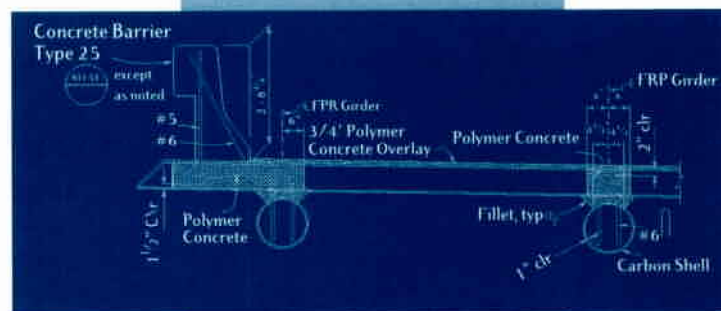
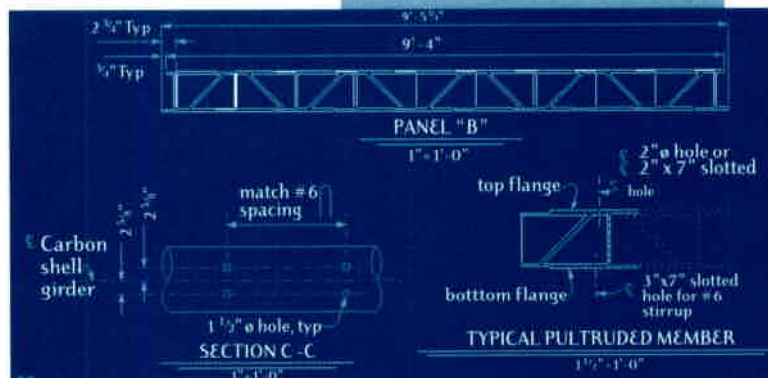
The cost of the Kings Stormwater Channel Bridge is several times that of a conventional structure, but this is “one-off technology.” Costs are likely to drop substantially if the technology makes its way into general use. And because of the materials’ strength it is likely that life-cycle costs will tend to be lower; the material does not need paint and it is inert. There is nothing to rust.

Then, too, while there is an unquestionable beauty in the eye of a structures engineer, the Kings Stormwater Channel Bridge, as it stands today, with its tube and deck construction, probably would not please the average neighborhood beautification committee. If the technology gets into general use, we’ll have to find a way to make it more attractive.

Ultimately, the technology may have specific applications, rather than general ones. Because of its strength and lightness, its ease and quickness of construction appear to be superior to those of conventional structures, making it an obvious candidate for use in emergencies, especially those where construction is necessary under traffic.

“This technology shows a great deal of promise,” says Seaberg. “It’ll be several years before we have a picture of just how much promise it does have, but we are already using carbon composites and fiberglass column jackets for seismic retrofits. We are also planning to use them for the rehabilitation of the Schuyler Heim Lift Bridge decks in Long Beach.

“I expect that as we gain knowledge of how to use the material and industry learns of how to apply the technology to our market we will see a wide variety of applications, including bridge strengthening, repairs, sign structures, sign or light poles, and foundation piling,” says Seaberg. “I can envision other uses for typical installations, such as guard or barrier railing, guard rail posts, concrete reinforcement, large diameter pipes, prefabricated culverts, earth retaining systems and sound walls. The material is best used for high strength applications, especially if site conditions indicate that corrosion can be expected or if lightweight materials are necessary.”



Deck panels are manufactured by a process called “pultrusion,” pulling fiberglass through a resin bath and curing oven.



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